Finally, the British and American mental attitude toward their work seemed different. The British patients gave the impression of being, on the whole, self-contained, sober-minded men. The Americans in contrast were irresponsible boys to whom the adventure of coming to the war appealed strongly, and as a result they were casual in regard to their own care of themselves, taking every liberty with the general common-sense laws of personal hygiene.

From this comparison of medical casualties which were seen at a base hospital it appeared that the younger and less acclimatized American troops reacted in their development of diseases differently from the older and more seasoned British soldiers. Each body of men tended to have the same common illnesses but in different proportions. The British had many cases of trench fever and trench nephritis. These diseases were comparatively uncommon among the Americans. Respiratory infections and especially those following influenza, were more common and more serious among the Americans than among the British. The Americans had more casualties from diarrhea and indigestion, while the British suffered more from casualties due to physical strain and fatigue. Finally, the Americans more than the British seemed to develop an acute exacerbation of any chronic or latent disease to which they had any tendency from inheritance or previous history. These differences were due, among other reasons, to the fact that a certain number of men constitutionally unfitted to military life had not been weeded out from the Americans at the outset, and that there were too few officers and non-commissioned officers who were trained to enforce the disciplinary and hygienic measures designed to keep medical casualties as small as possible.

OPERATION OF SPINAL DECOMPRESSION.

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The operation of laminectomy for "spinal decompression" in cord lesions has a place in surgery comparable to that of cranial decompression in lesions of the brain. The value of operation for cranial decompression, especially that of subtemporal decompression in supratentorial lesions, has been well recognized for years. That laminectomy for spinal decompressions or for exploration is of equal if not greater value is not yet generally appreciated. It has in the past been employed but rarely, and then usually at the wrong time, and as a last resort when all other measures have failed and the nerve tissue irreparably damaged. And yet there can be no doubt that in patients having obscure lesions of the cord or in doubtful diagnoses an exploratory laminectomy, frequently terminating as a simple decompression, has been followed by remarkable improvement of the patient. The spinal operation has an advantage over the cranial decompression, for though a cranial decompression may be used for an exploratory procedure the lesion itself can rarely be removed through the original incision; so that a second operation, the formation of an osteoplastic flap, is frequently necessary. But in spinal laminectomy the major part of the cord at the supposed site of the lesion is before the eye of the operator for exploration, and spinal decompression, exploration and possible removal of a lesion can be carried out at the one operation. Furthermore, diagnosis and localization of cord lesions is more accurate than the lesions of the brain. With the advance in surgical technic of recent years spinal laminectomy for exploratory purposes is becoming more and more recognized as justifiable and of small risk.

It is the purpose of this paper to discuss the value of exploratory laminectomy in cases of doubtful diagnosis or lesions of obscure origin which can be localized, and the value of spinal decompression in certain selected cases of well-recognized forms of cord disease which formerly were not considered amenable to surgical interference. Fractures of the spinal column with loose or depressed bone fragments and extramedullary tumors have for years been subject to operation and will not be considered in detail.

RECENT FRACTURE. In recent fracture of the spinal column, with involvement of the cord, laminectomy is urgently indicated even though there is no evidence that bone fragments are compressing the cord substance. An early decompressive laminectomy will allow the removal of blood clot, but, what is more important, will avoid the compressive effect of edema in and about the cord, which is always present, and sometimes in large amount, after every trauma to the cord. By laminectomy is meant operation after the patient has recovered from the shock, twelve to thirty-six hours after injury. Of course, laminectomy should not be considered while the patient is in a condition of shock.

Naturally a simple bone decompression with opening of the dura will be of no avail to the cord fibers already destroyed by the trauma. But by removal of hemorrhage and edema by an early laminectomy the sound fibers and many of the damaged ones will be preserved which otherwise would be destroyed by the compressive effect of the edema. In the past the harmful effect of compression by edema in cord trauma has been overlooked. In several cases of fracture of the spine operated upon by the writer by early laminectomy the cord (which normally lies loosely within the dura) was so swollen and tense with edema and filled the dural sac so completely that it was necessary first to incise the dura at a point well away from the site of injury and allow the fluid to escape. This was necessary not only to avoid injury to the swollen cord by direct incision but also to prevent a possible extrusion of cord substance through the dural incision if made directly over the point of swelling. No one who has encountered a condition such as this could fail to be convinced that if not relieved by operation such intense compression, even though by fluid, must cause severe damage not only to the injured fibers but also to the normal ones.

That edema alone can cause severe compression of cord fibers was well demonstrated in experiments carried out on animals by the writer some years ago in an effort to determine the primary causative factor in spina bifida.[1] Through a small laminectomy wound at the cervical dorsal junction in rabbits and puppies salt solution in variable quantities was injected under the spinal membranes both by gravity method and by syringe at moderate increasing pressure. Escape of fluid upward was prevented by cotton pledgets. Shortly after the entrance of the salt solution there were signs of irritation in the lower extremities (jerking and twitching of hind legs), followed as more fluid was introduced, by paresis of the legs in varying degree in the different animals; in two cases this amounted to apparent total paralysis. As the experiments had a different objective in view (the formation of a spina bifida protrusion in the lower lumbar region), and the animals were chloroformed at the end of the experiment, there was no opportunity of learning whether restoration of function in the hind legs would have followed absorption or withdrawal of the salt solution. But leaving aside the severe paralysis caused by the injection of large amounts of the solution the irritation and paresis caused by the introduction of fluid under moderate pressure in a normal cord are indicative of the damage edema can produce on injured cord fibers and how it continues and augments the initial lesion or trauma.

Old Fractures. There are many patients with fracture of the spinal column and trauma of the cord on whom, for various reasons (failure to diagnose the fracture, refusal of operation by the patient and the still rather widely held opinion that early laminectomy accomplishes no good), no operation was performed. In many of these patients improvement later occurs, progresses in variable degrees and then ceases, the condition becoming stationary, with the patient more or less disabled. In others, following the initial improvement, retrogression sets in, the condition becoming steadily worse. In yet other cases (and these usually the ones of moderate injury) the initial improvement is slight or absent, and the signs of cord involvement become progressively pronounced. In a large proportion of these patients the roentgen rays will disclose no displacement or thickening of bone and operation, if undertaken, will confirm the negative roentgen-ray findings. And yet in many of these old cases of fracture a simple exploratory or decompressive laminectomy will often give astonishing and brilliant results. Then what was the cause of the disability? The initial injury, undrained hemorrhage in or about the cord, the formation of later scar tissue and adhesions about the cord and in the arachnoid and dura that lead to the formation of sacculations filled with fluid. I have seen patients in whom the arachnoid adherent at some points and with fluid-filled sacculations at other points had the appearance of multilocular cysts. This condition alone, by compression, is capable of giving rise to marked signs of cord impairment. When such a condition is encountered the arachnoids should be widely opened, adhesions divided to allow the proper flow and return of spinal fluid and to prevent sac or cyst formation. Under no circumstances should the attempt be made to dissect scar tissue from the cord. If this is attempted the condition will almost certainly be aggravated. As stated above, remarkable improvement will often follow an exploratory laminectomy even in those patients with old fracture of the spine. Two such cases were reported in a former article.[2] One of these, a coal miner who suffered a fracture in the lower spine from a fall of rock, had been an invalid for eighteen months, able only to get about with crutches. Six months after an exploratory and decompressive laminectomy he was able to do desk work, using neither crutches nor cane. He continued to improve so that two years after operation he returned to his work as a miner. Six months later he was killed by a second fall of rock.

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[1] Annals of Surgery, February 1915.

The condition of increased intraspinal pressure (due to accumulation in excess of cerebrospinal fluid), similar to the corresponding condition intracranially, is the one lesion above all others of the nervous system that can be most successfully and safely treated by surgical means. Strictly speaking, increased pressure, whether intracranial or intraspinal, is not an independent lesion or clinical entity, but is rather secondary to some underlying lesion. Yet it is so frequently met with, its power to damage the nerve cells and fibers so great, the signs of its presence so readily ascertainable and its removal so promptly followed by improvement, as almost to raise it to the dignity of a distinct disease entity.

MULTIPLE SCLEROSIS. That disseminated sclerosis, with its widespread and multiple lesion scattered throughout the white areas of the cord and brain stem, could be benefited by surgical intervention may well be doubted. And this is true in typical cases in which the optic disk pallor, nystagmus, tremor of hands, absent abdominal reflexes and spasticity of legs bear witness to the widespread nature of the disease. There are other cases of multiple sclerosis in which the signs point to a focussing of the disease process in the lower part of the cord, as shown by the greatly exag-

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[1] AM. JOUR. MED. SC., December, 1916, No. 6, clii, 865.

gerated tendon reflexes and marked spasticity of the legs and a definite increase of fluid at lumbar puncture and comparatively little involvement of the upper part of the brain stem, as disclosed by little or no tremor of hands, no nystagmus and absence of pallor of the optic disks. And in certain cases of this latter type remarkable improvement has followed a simple laminectomy. Some of these patients show a definite sensory level zone about the lower thorax or abdomen, leading to the assumption that we are dealing perhaps with a cord neoplasm. Indeed, the first of these cases reported below was operated on with that diagnosis in mind, and it was only after the dura was opened that the condition was recognized as multiple sclerosis. Improvement was so definite that the two following cases of undoubted multiple sclerosis of the edematous type just described were operated upon with positive improvement in one case and slight in the other. We have operated upon four such cases, two of which show definite improvement, the third an astonishing result, in that whereas the patient came into the hospital markedly disabled on crutches, he walked out three weeks following a decompressive laminectomy with a cane only. His present condition after two and a half years is definitely improved. The fourth case was one in which the sclerotic process followed severe trauma to the lumbar spine some years before and the roentgen rays disclosed marked thickening of the vertebral laminæ. He was operated upon because of the roentgen-ray findings rather than for multiple sclerosis. No improvement whatever followed.

While we cannot be positive as to the etiology of multiple sclerosis, there is much evidence to support the view that the predisposing cause is faulty metabolism, an absorption of toxins, probably of intestinal origin. Trauma to the spine, perhaps slight in character, may be regarded as the exciting cause, for the signs of the disease rather often follow closely upon the receipt of an injury and make their first appearance in the neighborhood of the trauma.

But whatever the cause the pathology of multiple sclerosis would lead us to doubt strongly that in the presence of a disease process so widespread and deep-seated in the cord, possible benefit could result from the creation of a gap in the bony canal and membranes by a simple laminectomy; and yet in view of the above and other reported cases it is not possible to doubt but that in certain selected patients having multiple sclerosis a decompressive laminectomy is followed by definite and marked improvement. Whether this improvement is due to the removal and subsequent subcutaneous wound drainage of cerebrospinal fluid, which was found to be far in excess of normal in all the above cases, or whether there is a real modification of the sclerotic patches by alteration of the blood supply following operation, is impossible of verification. In two of the above cases the cord was somewhat shrunken in size, and in all four there was an excess of fluid. Yet the fluid soon recollects. In the writer's opinion improvement was caused by increased nutrition of the cord due to alteration in the blood supply. That the improvement following decompression operations in multiple sclerosis is or will be permanent is open to question. Unless in an early exceptional case, it is difficult to conceive that such a measure will be followed by the disappearance of the sclerotic patches with restoration of function. Yet the improvement in the patients referred to above and in other patients has been so definite and relief so marked that even were the relief to last only two or three years the operation would, in the writer's opinion, be a valuable procedure in the face of the increasing spasticity and disability.

SYRINGOMYELIA. Syringomyelia is characterized by cavity formation within the cord, about the central canal. The basis of the process is a congenital anomaly of development affecting the central canal or nests of glia cells persisting from fetal life, remaining quiescent for years and under the influence of some irritant, proliferating with first tumor and later cavity formation about the central canal. The disease process is usually located in the cervical and upper dorsal region of the cord and is slowly progressive, extending in a longitudinal direction, and gives rise to marked and well-defined motor and sensory impairment. Trauma of the spinal column very frequently precedes the formation of syringomyelic cavities, which may become filled with fluid, compressing the cord substance and giving rise to severe sensory and motor impairment. Trauma of the spine also very frequently precedes the formation of tumor of the cord either intramedullary or extramedullary, while in frank, typical cases syringomyelia and cord tumor can be rather readily differentiated, yet in atypical conditions, such as a lateral position of the tumor or a sharply localized position of the syringomyelic cavity it may be impossible to make a positive diagnosis. Naturally, if the diagnosis is tumor, the only procedure possible is operation; and if at operation instead of tumor the condition is found to be a syringomyelic cavity distending the cord the proper procedure is to drain the cavity and keep it drained by a method described below. Indeed, in certain cases of well-developed syringomyelia in which the signs point to the existence of a single cavity which does not involve the bulb, as in the lower cervical or upper dorsal region, and when the increasing intensity of the symptoms point to progressive distention of the cavity with fluid rather than to a spread of the disease process, it is, in the writer's opinion, justifiable to operate for the drainage of the cavity. One such case operated upon two and a half years ago had flaccid atrophic paralysis of both arms and spastic paralysis of the legs, with dissociated-sensory disturbances. Impairment was such that the arms were almost useless, hanging loosely at the side, and he walked with difficulty. Laminectomy was performed in the lower cervical region and a funnel-shaped enlargement of the cord found extending from the fifth cervical to the first dorsal segments inclusive. A longitudinal incision of the cord in the midline allowed much fluid to escape; the cavity was over two inches long and about one-third inch in diameter. Fine strands of linen thread were introduced into the cavity and the ends carried upward through the laminectomy wound and implanted in the muscle. Improvement was observed before the patient left the hospital. He continued to improve during the first year following the operation, in that he was able to raise the arms to the head, comb his hair, feed himself, etc., but never gained the power of raising the arms above the head. He walked with a less spastic gait. Since then his condition has remained stationary.

Naturally, operation is not advised in all cases of syringomyelia, especially when atrophy is extreme, but only in those patients in whom the medulla is not involved and in whom the signs point to the existence of a single cavity, with increasing distention of fluid—in short, in the selected patients described above. Whether the relief obtained will be permanent is doubtful. Certainly, the marked improvement this patient has shown for two and a half years makes the operation a justifiable one in selected patients.

Unclassified Cases. In addition to these well-defined conditions of spinal-cord disease or lesions, which may be benefited by operation, cases of cord involvement are seen quite frequently, in which only a tentative or possibly no diagnosis can be made. The obscure origin of the lesion or the unusual nature of the cord symptoms may make a positive diagnosis impossible. Naturally, if improvement occurs shortly and steadily progresses operation would not be considered. But if the signs of cord impairment remain stationary or further impairment occurs an exploratory laminectomy is not only justifiable but is imperative, even though the nature of the lesion cannot be diagnosed. Though in some of these patients operation will disclose a condition that will not be benefited the risk of the operation is slight. In other patients decided benefit and at times brilliant results will be obtained. The history of the following case is interesting as illustrating the observations noted above:

S. G., aged thirty-one years, cabinetmaker. In September, 1917, a small abscess appeared in the left nostril and was incised. During the following three months abscesses appeared in succession in the left orbit, the left cheek and the left side of the neck back of the ear. The last abscess was not healed until January, 1918, at which time he complained of pain and stiffness of the neck. A diagnosis of cervical Pott's disease was made and the head and neck immobilized by a stiff brace, which he wore for six months. In June, 1918, five months after the brace was applied, he noticed a numbness of the right hand and weakness of the left arm and hand. In one month this had progressed to a left hemiplegia (face not involved), with sensory disturbances over the right half of the body (excluding the face). The condition was now diagnosed as luetic bone disease of the cervical vertebræ. Two blood Wassermanns at this time were negative, and later two blood Wassermanns and one spinal fluid Wassermann were also negative. Notwithstanding these findings salvarsan was given intravenously; no benefit followed. Two radiographs in July showed no apparent bone lesion. Seen by the writer in November, 1918, examination showed a left hemiplegia. He walked with difficulty, the legs being very spastic; left ankle-clonus and a left Babinski were present. The left arm also was spastic. Could raise the arm slightly and flex and extend the forearm slowly, but could not move the hands or fingers. On the right side there was tactile, thermal and pain hypesthesia on the inner side of the foot, leg, and in areas over the right thigh and trunk; marked hypesthesia of the right hand and in areas over the forearm; no total anesthesia. Two radiographs of cervical spine at this time showed apparently normal bone. As signs and symptoms were stationary an operation was not considered advisable at this time, and he was kept under observation. In January, 1919, he complained of beginning weakness of the right hand and arm, and an examination confirmed this. The right-sided sensory disturbances were unchanged. There was some tenderness to pressure in the left side of the neck at the level of the third cervical vertebra. The signs pointed to a lesion, nature unknown, at the level of the third and fourth cervical segments. Examination of the pharynx disclosed a small sinus running downward toward the body of the third cervical vertebra. In view of the beginning motor impairment of the right side of the body an exploratory operation was advised. Laminectomy was performed January 29, 1919. The laminæ of the fifth, fourth, third and part of the lamina of the second cervical vertebræ were removed. The dura was tense and deeply indented on the left side at the level of the third vertebra by a small projection of bone (exostosis) into the canal. This was removed and the dura rounded out. There was no evidence of other obstruction in the canal either above or below the field of operation. Dura incised and fluid spurted to a height of seven inches for ten to fifteen seconds despite the fact that both head and trunk were below the level of the incision. The exposed cord appeared normal and a probe passed upward and downward disclosed no intradural obstruction. The dura was reclosed and the wound was closed with one drain. The head and neck were immobilized by a molded plaster-of-Paris splint.

Eight days after operation he moved the left foot and left fingers more freely than for six months. Three weeks after operation he could flex and extend the fingers of the left hand separately and could put his hand on top of the head and walked with less difficulty. Four months after operation he walked well without a cane;

could use the left arm freely almost as well as the right arm, though somewhat awkwardly. Power in the left arm and leg was good and he could use the arm and leg almost normally, though a trifle uncertainly. Could write legibly though poorly. (He was left-handed.) His chief complaint was numbness of both arms and hands, but examination showed very slight hypesthesia. The areas of marked hypesthesia on the right leg were still present. The lower tendon reflexes were still marked, more so on the left side; left ankle-clonus was present, also a left Babinski. He is steadily improving. Even after operation I am unable to make a positive diagnosis of the lesion, but consider the following to be the most probable:

Osteitis of the second and third cervical vertebræ, with inflammatory reaction in cord meninges and retention of fluid, or thrombosis or pressure obstruction of the spinal vessels of the left side of the cord at the level of the second and third vertebræ.

TECHNIC OF LAMINECTOMY.—A vertical incision is made in the median line over the spinous processes. The muscles are incised close to the spinous processes on both sides and the incisions packed with hot gauze. With a broad-bladed periosteal elevator the laminæ are freed of muscles the whole length of the wound and a large self-retaining retractor inserted, which effectually checks venous bleeding and presents a comparatively dry field. The ligaments of the spinous processes are then divided and the processes removed by large special ronguers. The laminæ are rongeured away, laying open the spinal canal and exposing the dura. This completes the first stage of the operation and should be performed rapidly, both to minimize the loss of blood and to afford leisure for the delicate and sometimes tedious intradural procedure. The spinal canal is then explored by means of a probe or grooved director on all sides both above and below the operating field. Naturally, if suppuration is encountered or suspected in the spinal canal, extradural, the dura would not be opened; otherwise the dura is incised and a similar exploration carried out. If a removable lesion is found, as tumor or blood-clot, the dura may be reclosed. If the operation is a decompression one for a known lesion, such as fracture or multiple sclerosis, the dura is left unclosed to permit of decompression. Unless the dura is opened and allowed to remain open, bone decompression will avail nothing. In other conditions also the dura should not be closed, *e. g.*, intramedullary tumor exposed by splitting the posterior columns or for drainage of a distended syringomyelic cavity. The third stage of the operation is the closure of the wound in layers by chromic gut, using care to have the muscle layers well approximated, leaving no dead spaces. I prefer a single drain of rubber tissue running to the depths of the wound for the drainage of wound fluid. This is removed in twenty-four to forty-eight hours. A molded plaster-of-Paris splint will give support to the spinal column and comfort to the patient. There is little or no pain following the operation, and opiates are seldom necessary.